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Searching for Light Dark Matter and Dark Sectors with the NA64 experiment at the CERN SPS

Since its approval in 2016, NA64 has pioneered LDM searches with electron [1], positron [2], muon [3], and hadron [4] beams. The experiment has successfully met its primary objectives, as outlined in the EPPS input (2018), and even exceed them producing results that demonstrate its ability to operate in a near-background-free environment. The Physics Beyond Collider (PBC) initiative at CERN recognize NA64's contributions as complementary and worthy of continued exploration. Its key advantage over beam-dump approaches is that the signal rate scales as $(\text{coupling})^2$ rather than $(\text{coupling})^4$, reducing the required beam particles for the same sensitivity.

To fully exploit the NA64 physics potential, an upgrade during LS3 will enable NA64 to run in background-free mode at higher SPS beam rates. Planned upgrades include (a) improved detector hermeticity with a new veto hadron calorimeter, (b) enhanced particle identification with a synchrotron radiation detector, and (c) increased beam rates via upgraded electronics.

With the recently strengthened NA64 collaboration, stable operations and timely data analysis are planned for LHC Run 4. The expected $\sim 10^{13}$ electrons, $\sim 10^{11}$ positrons (40 and 60 GeV), and $\sim 2 \times 10^{13}$ muons on target will allow NA64 to explore new light dark matter regions, with the potential for discovery or conclusive exclusion of many well-motivated LDM models.

References

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[4] Yu. M. Andreev et al. Dark-Sector Search via Pion-Produced η and η'Mesons Decaying Invisibly in the NA64h Detector. Phys. Rev. Lett., 133(12):121803, 2024.

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